

LEADFRAME AND METHOD FOR REDUCING MOLD COMPOUND ADHESION PROBLEMS

TECHNICAL FIELD

This invention related to injection molding of integrated circuit packages, and, more particularly, to devices and methods for reducing problems resulting from mold compound adhering to integrated circuit leadframes.

BACKGROUND OF THE INVENTION

As shown in Figure 1, integrated circuits are typically encapsulated in a package 10 of a suitable material, such as epoxy, from which conductive leads 12 project. Although the leads 12 are shown in Figure 1 as being conductors that project laterally and then downwardly, other lead configurations are in common use.

The encapsulation of the integrated circuit is typically performed by placing the integrated circuit in a mold then injecting a mold compound into the mold. A typical integrated circuit injection mold 20 is shown in Figure 2. The mold 20 includes a rectangular upper mold section 26 and a matching lower mold section 28, each of which have a series of mold cavities 36, 38, respectively, formed in respective adjoining mold surfaces 30, 32. Each of the adjoining pairs of mold cavities 36, 38 generally encapsulate a single integrated circuit, although it is possible to encapsulate several interconnected integrated circuits in a single mold cavity pair. Eight mold cavities 36, 38 are shown in Figure 2, but a greater or lesser number of mold cavities may be formed in conventional mold sections. The mold cavities 36, 38 are typically rectangular to match the desired shape of the integrated circuit package 10 (Figure 1), but other shapes are also possible.

In practice, before the integrated circuits are placed in respective pairs of mold cavities 36, 38, they are attached to a leadframe, and the integrated circuit and leadframe are placed between the mold sections 26, 28. A typical leadframe 40 is shown in Figure 3A. The leadframe 40 includes several leadframe sections 44 corresponding in number to the number of pairs of mold cavities 36, 38, and

corresponding in size and shape to the size and shape of the mold cavities 36, 38. A single leadframe section 44 is shown in Figure 3B. With reference to Figure 3B, each leadframe section 44 includes a central mounting plate 46 to which an integrated circuit 48 is mounted by suitable means, such as adhesive tape (not shown). Each leadframe section 44 also includes a plurality of inner leads 50 projecting from each side of the central mounting plate 46 to a respective gasket strip 52, and a plurality of outer leads 56 aligned with respective inner leads 50 extending from the gasket strips 52 to an outer strip 58. The outer leads 56 are what eventually form the leads 12 shown in Figure 1. The leadframe 40 also includes leadframe rails 60, 62 extending along the longitudinal edges of the leadframe 40. As explained in greater detail below, after the package 10 has been formed, the portion of the leadframe 40 extending beyond the outer leads 56 and the leadframe rails 60, 62 are removed. As a result, the only portion of the leadframe 40 extending beyond the package 10 are the outer leads 56 (*i.e.*, 12), as shown in Figure 1.

The leadframe 40 to which the integrated circuit 48 is attached is placed in the mold 20 between the mold sections 26, 28, with each leadframe section 44 aligned with a respective pair of mold cavities 36, 38. The leadframe 40 is also placed in the mold 20 so that the gasket strips 52 and leadframe rails 60, 62 extend around the cavities 36, 38 in contact with the mold surfaces 30, 32. As a result, the leadframe 40 acts as a gasket to retain material within the cavities 36, 38.

After the leadframe and integrated circuit 48 have been placed in the mold 20, a mold compound is injected into each pair of the cavities 36, 38 through a respective injection inlet 70 (Figure 2) provided for each pair of mold cavities 36, 38 at one edge thereof. The injection inlets are formed in either or both of the mold sections 26, 28. The injection inlets 70 provide a path for the mold compound, generally an epoxy compound, to be injected into the mold cavities 26, 28. The mold compound attempts to displace air in the mold cavities 36, 38, and this air must therefore be vented from the cavities 36, 38. For this purpose, mold vents 74 are formed in either or both of the mold sections 26, 28 through an edge of each pair of mold cavities 36, 38 opposite the injection inlets 70.

After the mold compound has solidified, the mold sections 26, 28 are separated to allow the leadframe 40 and packages 10 to be removed from the mold 20. As previously explained, the leadframe 40 forms a gasket between the mold sections 26, 28 to prevent the mold compound from leaking out of the mold cavities 36, 38. In practice, however, some of the mold compound leaks past the gasket strip 52 onto the outer leads 56 and the outer rails 58. Some of the mold compound also leaks onto the leadframe rails 60, 62. The undesired mold compound on these exposed portions of the leadframe 40 is known as mold compound "flash."

Throughout the manufacturing process, the leadframe 40 may be exposed to various contaminants, such as the mold compound flash, as described above. These contaminants, including mold compound flash, are removed from the leadframe 40 in a deflashing procedure after the leadframe 40 and packages 10 have been removed from the mold 20. The deflashing procedure also cleans the leadframe 40 so the leadframe 40 can be properly electroplated, as described below.

Several varieties of deflashing procedures may be used. One conventional deflashing procedure uses an electrolytic deflash machine (not shown) that consists of two main components, an electrolytic deflash section and a high pressure rinse section. The electrolytic deflash section includes a deflash cell in the form of a box that is lined with iridium oxide coated titanium plates. The plates become anodes when they are connected to a positive voltage. An electrolyte is pumped into the deflash cell from a mixing tank to immerse the plates. A stainless steel conveyor passes through the deflash cell just over the electrolyte. The conveyor becomes the cathode when it is connected to the negative voltage through copper brushes. The leadframes 40 are suspended vertically from the conveyor so that they are immersed in the electrolyte. An electrical current is passed through the electrolyte to ionize some of the water in the deflash solution, thereby creating positively charged and negatively charged ions. The positively charged ions (H^+) migrate to the negatively charged leadframes 40. When the hydrogen ions reach the surface of the leadframes 40, they gain an electron and join together to create hydrogen gas bubbles. The rapid evolution of hydrogen bubbles on the surface of the leadframes 40 causes sufficient agitation to loosen the surface

contamination. After the rapid evolution of hydrogen bubbles loosens the surface contamination, the leadframes 40 are transported to the high pressure rinse section where they are carried through a high pressure water rinse. The high pressure rinse blasts away the loosened surface contamination from the leadframes 40.

5 Although the electrolytic deflash procedure is described in some detail herein, other conventional deflash procedures may be used. For example, the leadframe 40 may be sprayed with abrasive particles in a process similar to sandblasting. The mold compound flash may alternatively be removed from the leadframe 40 by high intensity laser radiation or some other means.

10 After the deflashing procedure, the leadframe 40 is typically electroplated with a lead/tin alloy. The alloy prevents oxidation of the leadframe 40 and promotes the solderability of the leadframe 40. The leadframe 40 may be fabricated from copper, for example, and oxidation would increase its contact resistance if the leadframe 40 was not electroplated.

15 Regardless of the deflashing procedure that is used, the deflashing procedure often fails to adequately remove the flash from the leadframe 40. Instead, although some of the flash is removed, an unacceptable amount commonly adheres to the leadframe 40, particularly on the leadframe rails 60, 62, which are the exposed surfaces of the leadframe 40 having the largest area. This flash remaining on the
20 leadframe 40 can prevent the leadframe 40 from being properly electroplated. Also, the remaining flash can cause a number of problems in subsequent productions stages, as explained below.

 After undergoing the deflashing and electroplating procedures, the leadframe 40 undergoes a trimming and forming procedure. This procedure is generally
25 accomplished using a trimming and forming tool that cuts the outer rails 58 and leadframe rails 60, 62 from the leadframe 40, thereby leaving only the outer leads 56 as exposed portions of the leadframe. In the forming procedure, the outer leads 56 are bent to the configuration of leads 12 shown in Figure 1.

 The final manufacturing procedure is a visual inspection of the package
30 10 and leads 12. This procedure is generally performed using a vision system, such as a

video camera coupled to a computer that has been programmed with software to examine the package and leads 12 for such parameters as lead spacing and bending form.

As mentioned previously, an unacceptable amount of mold compound flash commonly remains on the leadframe 40 after the deflashing procedure. This flash can flake off from the leadframe 40 during the trimming and forming procedure, resulting in debris that can interfere with the operation of the trimming and forming tool used to perform the trimming and forming procedure. It is therefore necessary to frequently clean the flash debris from the trimming and forming tool, which requires manpower and takes the trimming and forming tool out of service for the period of time needed to complete the cleaning operation. The flash debris can also increase the maintenance required for the trimming and forming tool and shorten its useful life. A significant amount of flash debris can also remain on the package 10 and leads 12 after the trimming and forming procedure, thereby interfering with the operation of the vision system that inspects the package 10 and leads 12. For example, flakes of flash debris finding their way onto a lens of the vision system may obscure the view of the package 10 and leads 12. Flash debris flakes may also cause false inspection results that may cause unwarranted rejection of an integrated circuit. For example, a flake of flash debris on a lead 12 may cause the vision system to interpret adjacent leads to be too closely spaced to each other.

There is therefore a need for a device and method that substantially prevents mold compound flash debris from interfering with subsequent processing steps.

SUMMARY OF THE INVENTION

A leadframe is adapted for use with an injection mold having a plurality of mold cavities into which a mold compound is injected. The leadframe includes a pair of leadframe rails extending along opposite sides of the leadframe. The mold compound adherence properties of the leadframe rails are adjusted so that the mold compound adheres to the rails either relatively well or relatively poorly. By adhering

relatively well to the leadframe rails, the mold compound flash does not flake off from the rails during the trimming procedure. As a result, the mold compound flash is removed with the removal of the trimming of the leadframe rails from the package. By adhering relatively poorly to the leadframe rails, substantially all of the mold compound
 5 flash is removed from the leadframe rails during the deflashing procedure. As a result, there is virtually no mold compound flash on the leadframe by the time the trimming and forming procedure is performed. As a result, no flash debris is created during the trimming and forming procedure. The mold compound adherence properties may be adjusted by various means, such as altering the surface properties or materials of the
 10 leadframe rails or by creating apertures in the leadframe rails.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an isometric view of a conventional integrated circuit package.

Figure 2 is an exploded isometric view of an injection mold used to mold
 15 integrated circuit packages.

Figures 3A and 3B are top plan views of a conventional lead frame used in the injection mold of Figure 2 to mold integrated circuit packages of the type shown in Figure 1.

Figure 4 is an isometric view of a leadframe section according to one
 20 embodiment of the invention that facilitates the prevention of mold compound flash debris.

Figure 5 is an isometric view of one embodiment of the leadframe section of Figure 4 according to the present invention.

Figure 6 is an isometric view of another embodiment of the leadframe
 25 section of Figure 4 according to the present invention.

Figure 7 is an isometric view of still another embodiment of the leadframe section of Figure 4 according to the present invention.

Figure 8 is an isometric view of an injection molding machine using one of the leadframes embodiments of Figures 4-7 according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

One embodiment of a leadframe 80 that facilitates the prevention of mold compound flash debris is shown in Figure 4. Many of the features of the leadframe 80 are identical to those of the leadframe 40 shown in Figure 3. Therefore, in the interest of brevity, these features have been provided with the same reference numerals, and an explanation of the structure and function of these features will not be repeated.

The effectiveness of the leadframe 80 is based on the discovery that the leadframe rails 60, 62 (Figure 3) found on conventional leadframes, like the leadframe 40 shown in Figure 3, cause mold compound to bond to the rails 60, 62 too well to be adequately removed by conventional deflashing procedures but not well enough to substantially remain on the leadframe rails 60, 62 during the trimming and cutting procedures. Based on this discovery, mold compound flash debris can be substantially prevented by altering the mold compound adherence properties of the leadframe rails 60, 62. More specifically, the mold compound adherence properties of the leadframe rails 60, 62 may be adjusted so that the mold compound better adheres to the rails 60, 62. By adhering relatively well to the leadframe rails 60, 62, the mold compound flash does not flake off from the rails during the trimming and forming procedure. As a result, the mold compound flash is removed with the trimming of the leadframe rails 60, 62 from the package 10. Also, since the mold compound flash adheres well to the leadframe rails 60, 62 and is removed with the leadframe rails 60, 62, it may be possible to entirely dispense with the deflashing step.

Paradoxically, mold compound flash debris can also be substantially prevented by adjusting the mold compound adherence properties of the leadframe rails 60, 62 so that the mold compound adheres to the rails 60, 62 relatively poorly. By adhering relatively poorly to the leadframe rails 60, 62, substantially all of the mold compound flash is removed from the leadframe rails 60, 62 during the deflashing procedure. As a result, there is virtually no mold compound flash on the leadframe 40 by the time the trimming and forming procedure is performed. Thus, by adjusting the

mold compound adherence properties of the leadframe rails 60, 62 in either direction, substantially no flash debris is created during the trimming and forming procedure.

The leadframe 80 shown in Figure 4 differs from the conventional leadframe 40 of Figure 3 by having leadframe rails 82, 84 that have formed therein or thereon respective adherence treated areas 88. The adherence treated areas 88 are specifically adapted to cause the mold compound to adhere well to the rails 82, 84 in the adherence treated areas 88. This relatively strong attraction between the mold compound and the adherence treated areas 88 causes any mold compound deposited on the rails 82, 84 during the molding procedure to remain on the rails 82, 84 during the trimming and forming procedure. As a result, no mold compound flash debris is formed, as previously explained.

In one embodiment 80' of the leadframe 80 shown in Figure 5, the adherence treated areas 88 comprises sets of apertures 90 formed in the leadframe rails 82, 84. The apertures 90 may be formed by any means, such as by stamping, etching, laser cutting, or by other means. The apertures 90 are filled with mold compound during the molding process so that the mold compound is held against opposite surfaces of the leadframe rails 82, 84 by mold compound extending through the apertures 90. As a result, the mold compound is more securely attached to the leadframe rails 82, 84. Although the apertures 90 are shown in Figure 5 as being elongated transversely to the longitudinal axes of the rails 82, 84, the apertures 90 may have other shapes or orientations. Further, although the apertures 90 are shown in Figure 5 as being arranged in two groups each containing three apertures 90, different numbers of apertures grouped in any manner may alternatively be used.

Another embodiment of a leadframe 80'' according to the present invention is shown in Figure 6. The leadframe 80'' uses as the adherence treated areas 88 respective surface treatment areas 94 on the leadframe rails 82, 84. Standard surface finish for a leadframe fabricated from copper is typically $Ra=0.07$ micrometers. In the embodiment shown in Figure 6, the surface treatment areas 94 have a surface roughness increased by mechanical treatment, such as by stamping, knurling, or engraving, by chemical treatment, or some other means to increase surface area and therefore increase

adhesion per unit area. The surface treatment area 94 of increased roughness causes the mold compound to be more securely attached to the leadframe rails 82, 84 so the mold compound remains on the leadframe rails 82, 84 during the trimming procedure. As a result, there is substantially no mold compound flash debris formed during the trimming
 5 procedure. The roughened surface treatment areas 94 are preferably formed on both surfaces of each of the leadframe rails 82, 84.

As an alternative to having surface treatment areas 94 that cause the mold compound to be *more* securely attached to the leadframe rails 82, 84, the surface treatment areas 94 may causes the mold compound to be *less* securely attached to the
 10 leadframe rails 82, 84. As a result, substantially all of the mold compound is removed from the leadframe rails 82, 84 during the deflashing procedure so no flash debris can be formed during the trimming and forming procedures. The surface treatment areas 94 may be made to adhere less securely to the mold compound by, for example, reducing the surface roughness by some method, such as by mechanical or chemical polishing of
 15 the leadframe rails 82, 84 in the surface treatment areas 94. As a result, the surface treatment areas 94 are substantially smoother than the remainder of the leadframe rails. The surface treatment areas 94 that adhere less securely to the mold compound are preferably formed on both surfaces of each of the leadframe rails 82, 84

Still another embodiment of a leadframe 80''' according to the present
 20 invention is shown in Figure 7. The leadframe 80''' uses as the mold compound adherence treated areas 88 respective surface treatment areas 96 of the leadframe rails 82, 84 formed from a different material from the remainder of the rails 82, 84. The surface treatment areas 96 may be formed by any means, such as by coating respective areas of the rails 82, 84 with a suitable material, bonding or otherwise attaching
 25 respective panels of a suitable material to areas of the rails 82, 84, creating respective apertures in the rails 82, 84 and inserting a panel of suitable material in each aperture, or by other means. The material used to form the surface treatment areas 96 may be any material to which the mold compound adheres either relatively more securely or relatively less securely. For example, if the remainder of the leadframe 80''' including
 30 the leadframe rails 82, 84 are formed from a nickel-based alloy, the material used to

form the surface treatment areas 96 may be copper since it has been found that conventional mold compounds adhere better to copper than they do to nickel-based alloys. By way of further example, the surface treatment areas 96 may be areas of the leadframe rails 82, 84 that are coated with a surface lubricant, such as Teflon® or a
 5 conventional mold release compound, that causes the mold compound to adhere less securely to the leadframe rails 82, 84. Again, the surface treatment areas 96 are preferably formed on both surfaces of the leadframe rails 82, 84.

It should also be mentioned there is no specific limits to the sizes of the adjusted adherence areas 88, and the sizes or shapes of the adjusted adherence areas 88
 10 may be different from those shown in Figures 4-7.

One embodiment of a molding machine 100 using a mold 20 of the type shown in Figure 2 and an embodiment of the leadframe 80 shown in Figures 4-7 is schematically shown in Figure 8. The molding machine 100 is of conventional design, and includes a material reservoir 106 containing a supply of mold compound that is to
 15 be injected into the mold 20. The molding machine 100 also includes an injection mechanism 108 for forcibly injecting the mold compound from the material reservoir 106 into the mold 20. The molding machine 100 also includes a heating mechanism 110 for heating the mold 20. By using an embodiment of the leadframe 80 specially adapted prevent the formation of mold compound flash debris, the downtime of
 20 trimming and forming machines (not shown) subsequently used to process the leadframe is reduced, and the performance of vision systems subsequently used to inspect the resulting integrated circuit is enhanced.

From the foregoing it will be appreciated that, although specific embodiments of the invention have been described herein for purposes of illustration,
 25 various modifications may be made without deviating from the spirit and scope of the invention. Accordingly, the invention is not limited except as by the appended claims.